Fishery Data Series No. 95-28

Fishery Surveys during the Recreational Fishery for Late-run Sockeye Salmon in the Kenai River, 1994

by

Mary A. King

November 1995

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

A creel survey was conducted from 1 July through 15 August 1994 on the Kenai River downstream of the Soldotna Bridge to estimate recreational angler effort, catch, harvest, and snag of sockeye salmon *Oncorhynchus nerka*. The creel survey area was divided into two strata: the Soldotna Bridge to the sonar counters (Stratum A), and the sonar counters to the Warren Ames Bridge (Stratum B). Recreational anglers exerted an estimated 53,844 angler-hours to harvest an estimated 11,624 sockeye salmon in Stratum A, and an estimated 63,204 angler hours to harvest an estimated 11,773 sockeye salmon in Stratum B. Most fish caught were retained. Total catch exceeded the harvest for both strata by only 5%-8%. The number of fish snagged was estimated to be 5,582 in Stratum A and 8,709 in Stratum B. The total inriver return (sonar estimate plus harvest estimate for Stratum A) was estimated to be 1,015,070 sockeye salmon.

A second survey (a fishery survey) was conducted on the Kenai River from the Warren Ames Bridge to Kenai Lake from 15 July to 15 August 1994. The river was divided into three strata for the fishery survey: the downriver section was from the Warren Ames Bridge to the Soldotna Bridge (Strata A and B of the creel survey combined), the midriver section was the Soldotna Bridge to Skilak Lake, and the upriver section was Skilak Lake to Kenai Lake. Residency of anglers contacted in this survey was 17% Kenai Borough, 37% Alaska, 42% U.S., and 4% other. Most anglers started their fishing day between 0800 and 1200 hours. Anglers exiting the fishery from the upriver section tended to have longer fishing days than anglers exiting the downriver and midriver sections.

Sixty-two percent of anglers harvested no fish, 14% harvested one fish, 7% harvested two fish, and 17% harvested three or more fish. Anglers had better success harvesting sockeye salmon in the midriver section than the upriver or downriver sections: over half of anglers in the midriver section harvested at least one fish while only about a third of the anglers in the upriver and downriver sections harvested at least one fish. In 1994, a three-fish bag limit reduced harvest by 17% but a bag limit of two or one would have reduced harvest by 23% or 53%, respectively. Angler success showed a positive relationship with the sonar counts. When fish passage exceeded the median sonar count (20,973) angler success was highest; below the median count angler success was lowest and any alteration of the bag limit would have had little effect on the harvest.

Key words: Kenai River, sockeye salmon, creel survey, fishery survey, effort, harvest, snag, bag limit, demographics, sonar count, *Oncorhynchus nerka*.

INTRODUCTION

BACKGROUND

The Kenai River (Figure 1), a glacial river, is the most heavily fished river in Alaska, supporting 13% of Alaska's recreational fishing effort (Mills 1994). Targeted species, both resident and anadromous, include Dolly Varden *Salvelinus malma*, rainbow trout *Oncorhynchus mykiss*, chinook salmon *O. tshawytscha*, coho salmon *O. kisutch*, sockeye salmon *O. nerka*, and pink salmon *O. gorbuscha*.

In recent years sockeye salmon have become one of the major targeted species in the Kenai River. Historically, sockeye salmon were harvested in the mainstem Kenai River using snagging techniques. When snagging was prohibited in the 1970s anglers applied the techniques used in the clearwater fishery of the Russian River and soon developed effective methods for sport harvest of sockeye salmon in the Kenai River.

Sockeye salmon return annually to the Kenai River in two temporal components, termed early and late runs. The early-run stock typically enters the river in June and the late-run stock typically begins entering the river in early July, continuing into August. The early-run stock spawns primarily in the Russian River drainage. The late-run stock spawns throughout the Kenai River drainage, particularly in the mainstem Kenai River, Skilak Lake and Kenai Lake.

Sport fishing effort during the recreational sockeye salmon fishery on the Kenai River is primarily directed at the late-run stock. Prior to 1987 annual harvest of the late run was less

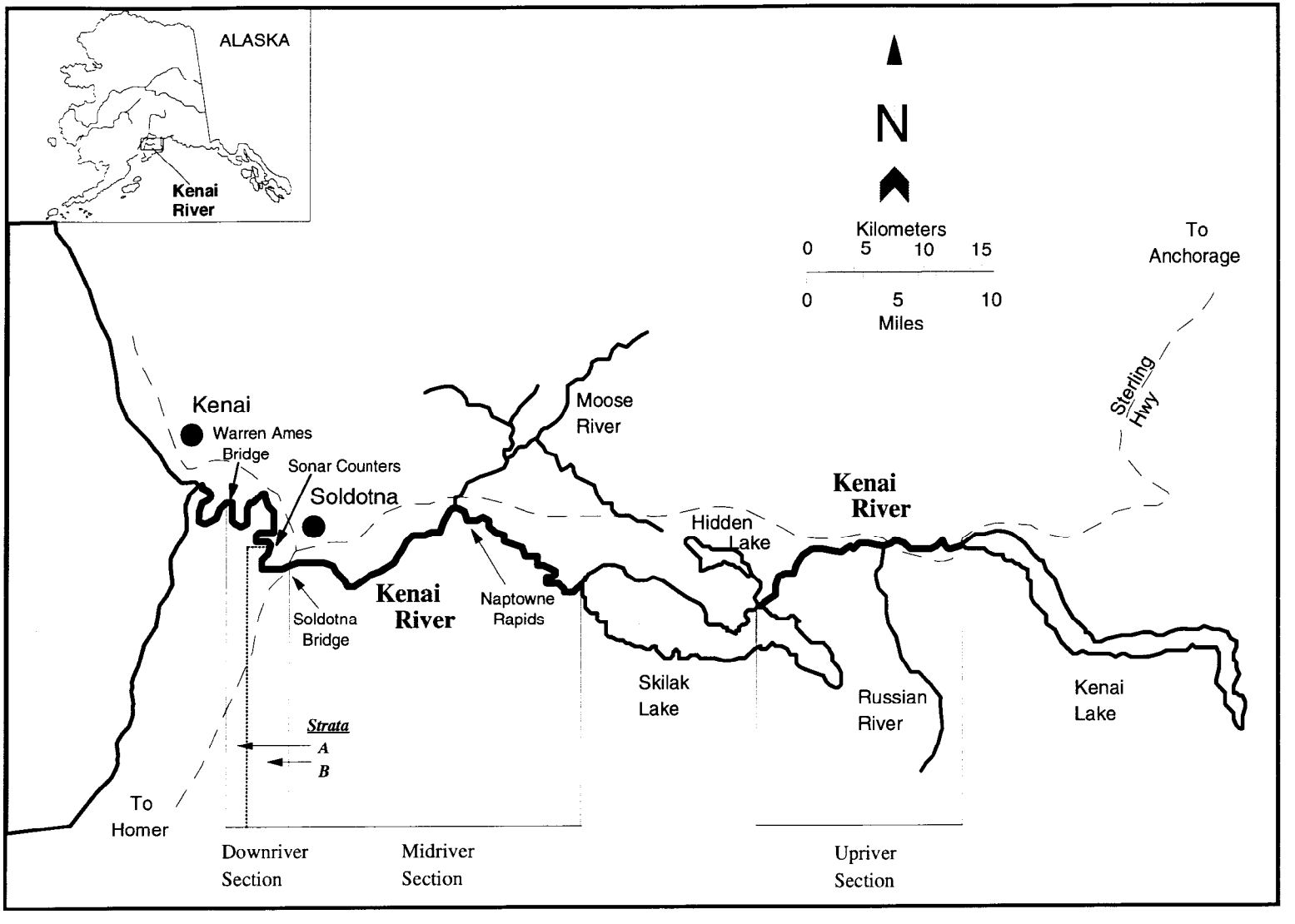

Figure 1.-Map of the Kenai River drainage.

than 70,000 fish (Mills 1979-1987). In 1987 harvest increased to over 230,000 fish with annual harvest now exceeding 120,000 fish (Mills 1988-1994; Figure 2). Although no effort estimates are available for the Kenai River sockeye salmon recreational fishery prior to this study, observation indicates that participation in the fishery has increased dramatically.

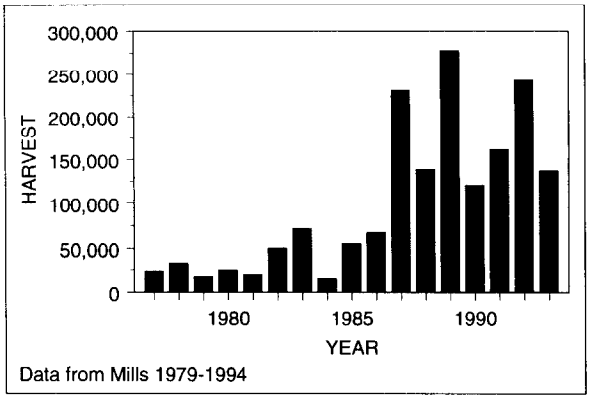

Figure 2.-Annual harvest of sockeye salmon in the Kenai River during the recreational fishery, 1977-1993.

Harvest by the sport fishery is estimated postseason through the Statewide Harvest Survey, a mailout questionnaire. Final estimates are not available until fall of the following year.

A major commercial fishery in the marine waters of Upper Cook Inlet (UCI) also targets the late-run sockeye salmon return to the Kenai River. UCI fisheries harvesting sockeye salmon of Kenai River origin include the Central District drift and set gillnet fisheries, with a combined mean harvest from 1981-1993 of 3.0 million (range: 0.5-7.2 million) (D. Waltemyer, Alaska Department of Fish and Game, Soldotna, personal communication).

The commercial harvest is determined from fish tickets with the data available within days after a commercial fishing period; the final estimate is calculated postseason.

The late-run stock is also subjected to harvest by personal use dip net and set gillnet, subsistence, and native educational subsistence fisheries. These fisheries have a combined annual harvest of less than 60,000 fish.

Harvests by the personal use fishery are estimated postseason through the Statewide Harvest Survey. Final estimates are not available until fall of the following year. The subsistence harvest is determined postseason after participants return their harvest records. The harvests in the native educational subsistence fishery are reported postseason as well.

The inriver return of late-run sockeye salmon is monitored by sonar counters at river kilometer 31.4 (river mile 19.5). These provide daily estimates of fish passage.

Subsistence fisheries, which have priority use by statute, have been permitted intermittently in recent years. Subsistence gillnet and dip net fisheries for Kenai River salmon stocks were allowed in 1992 and 1994. Legal concerns prevented a subsistence fishery in 1993.

The recreational fishery is managed under the Kenai River Sockeye Salmon Management Plan (Appendix A) adopted into regulation by the Board of Fisheries (BOF) in 1980. This plan establishes a desired inriver escapement goal of 400,000-700,000 sockeye salmon enumerated at the sonar counters. If the projected sonar count is less than 400,000, the recreational fishery for sockeye salmon is to be closed. If the projected sonar count is between 400,000 and 700,000, the recreational fishery is to be managed to harvest 10% or less of the return upstream of the counters. If the projected sonar count is greater than 700,000, the recreational fishery is liberalized

with the daily bag limit of sockeye salmon increasing from three fish to six fish.

The personal use dip net fishery is managed under the Cook Inlet Personal Use Salmon Dip Net Fishery Management Plan (Appendix B), adopted into regulation by the BOF in 1981. This plan allows for a dip net fishery with a daily bag limit of six sockeye salmon when the projected sonar count exceeds 700,000.

At the 1992 Board of Fisheries meeting, concerns were voiced regarding the annual recreational harvest exceeding the 10% guideline level since 1986. The BOF directed the department to manage the 1993 fishery to comply with the 10% requirement of the Plan. The bag limit was reduced from three sockeye salmon to two and hours open to fishing were limited to 0600 to 2100 hours. The fishery was prosecuted with these directives until the sonar count surpassed 700,000. At that time hourly restrictions were lifted and the bag limit was liberalized to six fish. Although this management strategy brought the recreational harvest into compliance with the Plan, vocalized public dissent to the department, BOF, and the Legislature resulted in regulations for the 1994 season reverting to the former three fish bag limit with no hourly restrictions.

A Sockeye Salmon Task Force has been evaluating the Kenai River Sockeye Salmon Management Plan since 1993 and will propose revisions to the Plan to the BOF prior to the 1995 fishery.

Description of the Kenai River Sockeye Salmon Sport Fishery

The recreational fishery targeting late-run sockeye salmon in the Kenai River usually begins in early July as fish begin to enter the river; however, little effort is present in the fishery until after mid July when fish begin to enter the river in large numbers. Typically, participation in the fishery remains high until the end of the first week of August. Effort begins to decline after this.

The sockeye salmon fishery is typically a shorebased fishery with high concentrations of anglers at public access sites. In recent years there has been an increase in anglers using boats to access bank areas not accessible by the road system. The fishery occurs along the entire 132 km (82 mile) reach of the Kenai River from Cook Inlet to Kenai Lake (Figure 1). Effort concentrates in the lower river as fish begin to enter and then shifts gradually upstream with fish migration. There has been little participation by guided anglers, however there is a trend for guides to provide anglers with gear and then to "drop off" the anglers at various bank locations while the guide continues on with chinook salmon clients.

The common technique used by anglers is to drift a streamer fly which is weighted about 12 inches above the hook. The fly is cast upstream within 15 feet of the bank and allowed to drift downstream, to be retrieved and roll casted upstream again.

Prior to 1994, no creel survey had been conducted on this fishery. Consequently, there were no estimates of effort for the sockeye salmon sport fishery, although harvest is estimated in the Statewide Harvest Survey. The creel and fishery surveys were initiated to better assess angler harvest, effort, and success during the sockeye salmon sport fishery. Specifically, the surveys provide data to estimate the total inriver return downstream of the sonar counters and to determine the effectiveness of the three-fish bag limit to limit harvest and the effects of a more restrictive bag limit to further reduce harvest. Results also provide information for inseason management decisions.

Data on snagging of sockeye salmon were also needed. During the Sockeye Salmon

Task Force meetings, discussions included the possibility of retention of snagged fish to allow anglers to attain their bag limits more quickly, which would hasten their exodus from the fishery and possibly reduce damage to habitat.

Regulations Governing the Sport Fishery

In the Kenai River, sockeye salmon are categorized with "salmon other than chinook salmon" and have aggregate bag and possession limits. During 1994, the aggregate daily bag and possession limit was three salmon 41 cm in length or greater with no annual limit. This was liberalized to six fish on 2 August when the sonar count was projected to exceed 700,000, as directed by the Kenai River Sockeye Salmon Management Plan.

Objectives

The primary goal of the 1994 project was to estimate the inriver harvest of sockeye salmon by anglers in the Kenai River downstream of the sonar counter. The other goal was to determine the effectiveness of bag limits by estimating the catch and harvest success of the recreational sockeye salmon fishery. Specific objectives were to:

1. estimate the total harvest, catch, and release due to snagging (foul hooking) of late-run sockeye salmon by the recreational fishery in the mainstem Kenai River downstream of the Soldotna Bridge stratified into two areas, downstream of the sonar counter and upstream of the sonar counter to the Soldotna Bridge, from 1 July through 15 August 1994;
2. estimate angler effort on late-run sockeye salmon by the recreational fishery for the locations and time periods listed in Objective 1; and
3. estimate the distribution of harvest and catch success of sockeye salmon among anglers (angler-day) in the recreational sockeye salmon fishery from 15 July through 15 August 1994, in the mainstem Kenai River stratified into three areas: downstream of the Soldotna Bridge, between the Soldotna Bridge and Skilak Lake, and between Skilak Lake and Kenai Lake.

METHODS

Creel Survey

A roving creel survey (Bernard et al. *In prep*) was used to estimate sport fishing effort in units of angler-hours fished. Angler interviews were used to estimate harvest per unit of effort (HPUE, in units of numbers of sockeye salmon harvested per angler-hour fished), catch per unit of effort (CPUE, in units of numbers of sockeye salmon caught per angler-hour fished) and snag per unit of effort (SPUE, in units of numbers of sockeye salmon snagged per angler-hour fished). Harvest, catch, and snag were estimated as the product of the estimated effort and HPUE, CPUE, or SPUE, respectively. Harvest refers to fish legally hooked and retained by anglers as part of their creel. Catch refers to fish legally hooked and retained plus those reported to be released by anglers (excluding snag). Snag refers to fish which anglers foul hooked, landed, and released.

The creel survey was based on a stratified two-stage sample design and was conducted from 1 July to 15 August 1994. The survey encompassed the mainstem Kenai River downstream of the Soldotna Bridge to the Warren Ames Bridge, termed the downriver section. The downriver section was divided into two strata for the creel survey. Stratum A was defined as the Kenai River from the Warren Ames Bridge (rkm 8.1) to the sonar counter (rkm 31.4). Stratum B was defined as

the sonar counter (rkm 31.4) to the Soldotna Bridge (rkm 33.8). Days were the first stage units and angler trips were the second stage units. Each fishing day consisted of one 18-hour period (0400-2200 hours). Days were sampled systematically, randomly choosing the first day (either 1 July or 2 July) and sampling alternate days thereafter until 15 August.

Sampling levels were designed to estimate effort, harvest and catch to within ±25% of their true values 95% of the time. A total of 23 days were sampled, 16 days in July and 7 days in August. Some deviation from the schedule occurred due to mechanical breakdown and other duties such as public assistance or enforcement activities. Four people conducted the survey: two creel clerks who conducted shore angler counts from a boat in conjunction with responsibilities associated with the chinook salmon creel survey, and two access creel clerks who conducted interviews at designated access sites.

Three counts of anglers fishing from shore (shore anglers) were conducted during all scheduled sampling periods. The first count was randomly chosen to start on a whole hour between 0400 and 0900 hours. The two subsequent counts occurred at 6-hour intervals. Counts were conducted using a boat driven at a constant rate of speed through the length of the survey area, starting at one end of the area. The trip usually took 45 minutes or less to complete and every effort was made to ensure the trip was completed within 1 hour. Angler counts were considered instantaneous and reflected fishing effort at that time. During each count, the boat clerk recorded the total number of shore anglers in each geographic stratum.

Angler interviews were conducted during all scheduled sampling periods. This enabled angler counts (effort) to be related to angler interviews (HPUE, CPUE, and SPUE estimates). The interviews were conducted by two access clerks, each working a 9-hour shift (0400-1300 hours or 1300-2200 hours). During a shift an access clerk conducted interviews of completed-trip and -day anglers at three access sites, two in Stratum A and one in Stratum B.

Access clerks recorded the following information from anglers who had finished fishing for that trip (completed-trip anglers): (1) total hours fished, (2) total harvest by species, (3) total number released (legally landed and released) by species, and (4) total number snagged by species. If the angler had finished fishing for sockeye salmon on the Kenai River for the day (completed-day angler), excluding the Russian River fly-fishing-only area, then the access clerk also recorded a completed-day interview which included all of the above information as it pertained to the entire fishing day. In addition, each completed-day angler was queried as to whether this was a guided or unguided fishing trip (or day), the start time for the first fishing trip that day, and their residency: (1) local (Kenai Borough), (2) Alaska (other than Kenai Borough), (3) U.S. (other than Alaska), and (4) other.

Total effort, catch, harvest, and snag were estimated by expanding means over all days sampled in a stratum (i.e., Stratum A and Stratum B). During each sample day three counts were made and interviews collected for the entire day.

The mean number of anglers counted on day i in stratum h was estimated by:

$$\bar{x}_{hi} = \frac{\sum_{g=1}^{r_{hi}} x_{hig}}{r_{hi}}, \qquad (1)$$

where:

x_{hig} = the number of anglers observed in the gth count of day i in stratum h, and

r_{hi} = the number of counts on day i, which was three in each stratum.

Angler counts were taken systematically within each sample day. The variance of the mean angler count was estimated by:

$$\mathrm{Var}(\bar{x}_{hi}) = \frac{\sum_{g=2}^{r_{hi}} \left(x_{hig} - x_{hi(g-1)}\right)^2}{2r_{hi}(r_{hi}-1)}. \quad (2)$$

Effort (angler-hours) during day i in stratum h was estimated by:

$$\hat{E}_{hi} = L_{hi}\bar{x}_{hi}, \quad (3)$$

where:

L_{hi} = length of the sample day (= 18 hours) in each stratum.

The within day variance was estimated by:

$$\mathrm{Var}(\hat{E}_{hi}) = L_{hi}^2 \mathrm{Var}(\bar{x}_{hi}). \quad (4)$$

The mean effort of stratum h was estimated by:

$$\bar{E}_h = \frac{\sum_{i=1}^{d_h} \hat{E}_{hi}}{d_h}, \quad (5)$$

where:

d_h = number of days sampled in stratum h.

Days were sampled systematically in each stratum. The variance of mean effort among days was estimated by:

$$\mathrm{Var}(\bar{E}_h) = \frac{\sum_{i=2}^{d_h} \left(\bar{E}_{hi} - \bar{E}_{h(i-1)}\right)^2}{2d_h(d_h-1)}. \quad (6)$$

Total effort of stratum h was estimated by:

$$\hat{E}_h = D_h \bar{E}_h, \quad (7)$$

where:

D_h = total number of days (= 46 days) in each stratum.

The variance of total effort of each stratum in a two-stage design, omitting the finite population correction factor for the second stage, was estimated by (Cochran 1977):

$$\mathrm{Var}(\hat{E}_h) = (1-f)D_h^2 \frac{\mathrm{Var}(\bar{E}_h)}{d_h} + fD_h^2 \frac{\sum_{i=1}^{d_h} \mathrm{Var}(\hat{E}_{hi})}{d_h^2}, \quad (8)$$

where:

f = finite population correction factor for days sampled (= d_h/D_h).

Catch, harvest, and snag per unit of effort of each day sampled were estimated from angler interviews using the jackknife method to minimize the bias of these ratio estimators (Efron 1982). A jackknife estimate of CPUE (similarly HPUE and SPUE) was made for each angler by:

$$\mathrm{CPUE}^*_{hij} = \frac{\sum_{\substack{p=1 \\ p\neq j}}^{m_{hi}} c_{hip}}{\sum_{\substack{p=1 \\ p\neq j}}^{m_{hi}} e_{hip}}, \quad (9)$$

where:

c_{hip} = catches of all anglers interviewed in stratum h on day i except angler j,

e_{hip} = effort (hours fished) of all anglers interviewed in stratum h on day i except angler j,

m_{hi} = number of anglers interviewed in stratum h on day i.

The jackknife estimate of mean CPUE of day i was the mean of the angler estimates:

$$\overline{CPUE}^{*}_{hi} = \frac{\sum_{j=1}^{m_{hi}} CPUE^{*}_{hij}}{m_{hi}}, \quad (10)$$

and the bias corrected mean was:

$$\overline{CPUE}^{**}_{hi} = m_{hi}\left(\overline{CPUE}_{hi} - \overline{CPUE}^{*}_{hi}\right) + \overline{CPUE}^{*}_{hi}, \quad (11)$$

where:

$\overline{CPUE}_{hi}$ = the standard estimate of CPUE, or the sum of all catches over the sum of all hours fished in a day.

The variance of the jackknife estimate of CPUE was estimated by:

$$Var\left(\overline{CPUE}^{**}_{hi}\right) =$$

$$\frac{m_{hi}-1}{m_{hi}} \sum_{j=1}^{m_{hi}} \left(CPUE^{*}_{hij} - \overline{CPUE}^{*}_{hi}\right)^2. \quad (12)$$

Catch during each sample day was then estimated as the product of effort and CPUE by:

$$\hat{C}_{hi} = \hat{E}_{hi}\overline{CPUE}^{**}_{hi}, \quad (13)$$

and the variance by:

$$Var\left(\hat{C}_{hi}\right) = Var\left(\hat{E}_{hi}\right)\left(\overline{CPUE}^{**}_{hi}\right)^2 +$$

$$Var\left(\overline{CPUE}^{**}_{hi}\right)\hat{E}^2_{hi} - Var\left(\hat{E}_{hi}\right)Var\left(\overline{CPUE}^{**}_{hi}\right). \quad (14)$$

HPUE and SPUE were estimated by substituting harvest and snag, respectively, for angler catch in equations (9) through (12). Harvest and snag during sample day i were estimated by substituting the appropriate $HPUE_{hi}$ and $SPUE_{hi}$ statistics into equations (13) and (14). Total catch, harvest, and snag during stratum h were estimated using equations (5) through (8), substituting estimated catch (C_{hi}), harvest (H_{hi}), and snag (S_{hi}), respectively, during sample day i for the estimated effort (E_{hi}) during day i.

The estimate of total effort, catch, harvest, snag, and their respective variances, were summed across strata as these estimates were considered independent.

FISHERY SURVEY

A stratified roving fishery survey was conducted on the Kenai River from 15 July to 15 August 1994. The fishery was stratified into three sections: (1) downstream of the Soldotna Bridge, referred to as the downriver section (Strata A and B from the creel survey combined); (2) upstream of the Soldotna Bridge to Skilak Lake, referred to as the midriver section; and (3) between Skilak and Kenai lakes (excluding the Russian River fly-fishing-only area), referred to as the upriver section (Figure 1). A systematic sampling schedule was designed with strata being sampled on alternate days. A sample period/day was 9 hours in length with the start time alternating daily, beginning at 0400 or 1300 hours.

Angler interviews for the downriver section of the fishery survey were conducted by access clerks during the creel survey. Angler interviews in the midriver and upriver sections were conducted by two additional access clerks, each assigned to a stratum. To obtain the objective criteria, 403 completed-day angler interviews were required in each stratum (Thompson 1987). There were 15 access sites, 3 in the upriver, 6 in the midriver, and 6 in the downriver (of which 3 were sampled). The access clerk in the upriver section conducted interviews at all three access sites during a period. In the midriver section the access sites were divided into three categories: (1) those closest to Skilak Lake, (2) those in the middle stretch of the river, and (3) those nearest the Soldotna Bridge. The access clerk in the midriver section conducted interviews at three access sites, one randomly chosen from each category. Since the sockeye salmon fishery is

primarily shorebased, the access clerks used automobiles for transportation to access sites.

Access clerks interviewed only completed-day anglers. Anglers were queried as to whether or not guide services had been used, and as to their residency: (1) local (Kenai Borough), (2) Alaska (non Kenai Borough), (3) U.S. (non Alaska), and (4) other. Access clerks also collected data for (1) total hours fished that day, (2) time of day the angler began fishing, (3) total number of sockeye salmon harvested, (4) total number of sockeye salmon released, and (5) total number of sockeye salmon snagged. It was assumed that all completed-day anglers exiting the fishery from an access site when a technician was present would be interviewed. In situations when this was not possible, the access clerk randomly selected the anglers to be interviewed, being careful not to select only those with fish, and counted anglers that were not interviewed.

Estimates of the distribution of harvest, catch, and snag success of each sampled day were calculated by treating the interview data of that day as a simple random sample of the angler days for the fishery in that strata. "Distribution of catches" in a stratum were defined as the fraction p_k of angler days in the stratum in which "k" or more fish were caught, allowing "k" to be expressed as k = 1 to k_{max}. If k_{max} = 5, the one set of data was analyzed five times to obtain all possible fractions p_k in a set. The distribution of catch success for k = 0 was defined to be the proportion of angler days that resulted in the catch of no fish. Similar estimates were calculated for the distributions of harvest and snag.

The value of k_{max} for harvest was set to one fish more than the bag limit for sockeye salmon in effect during the survey (bag limit was increased from three to six fish on 2 August). The value of k_{max} for catch and snag was determined postseason. Since few anglers actually caught or snagged six or more fish (6+), k_{max} was set at this level.

Distribution of harvest, catch, and snag success of each sampled day was estimated as if the interview information was collected as a simple random sample of the fishery. The proportion of angler days of each distribution of harvest, catch, or snag success category (e.g., k = 0 fish, 1 or more fish, 2 or more fish, etc.) was estimated as a binomial proportion (Cochran 1977) by:

$$\hat{p}_k = \frac{m_k}{m} \tag{15}$$

where:

m_k = the number of completed-day anglers who caught (for distribution of catch success, harvested for distribution of harvest success, snagged for distribution of snag success) zero fish for k = 0, 1 or more fish for k = 1, 2 or more fish for k = 2, etc.; and

m = the total number of completed-day anglers sampled.

The variance of p_k was estimated as the variance of a binomial proportion (Cochran 1977), omitting the finite population correction factor since the total number of angler days was not estimated or known:

$$\hat{\mathrm{Var}}[p_k] = \frac{p_k(1-p_k)}{m-1}. \tag{16}$$

Chi-squared statistics were used to detect differences in catch, harvest, and snag success among 1-week time intervals and among strata. Linear regression analysis was used to determine a relationship between fish abundance (sonar counts) and angler harvest success.

RESULTS AND DISCUSSION

CREEL SURVEY

Angler counts and interviews were conducted on 23 of 46 possible days during the study period (1 July-15 August 1994).

Effort

During the late-run sockeye salmon recreational fishery, angler counts ranged from 0 to 415 with the highest count occurring on 23 July in Stratum B (Appendix C1).

The estimated effort in Stratum B (63,204 angler hours, SE = 3,485) was only slightly higher than that in Stratum A (53,844 angler hours, SE = 3,772), accounting for 54% and 46% of the total effort in the downriver section, respectively (Table 1). Angler effort in both strata exhibited two distinct simultaneous peaks on 23 July and 2 August (Figure 3).

Harvest and Catch

A total of 594 completed-trip angler interviews was conducted, 275 in Stratum A and 319 in Stratum B (Appendix C2).

Estimates of catch and harvest in Stratum A were 12,228 (SE = 1,801) and 11,624 (SE = 1,651), respectively, and in Stratum B were 12,740 (SE = 1,538) and 11,773 (SE = 1,446), respectively (Table 1). In each stratum catch and harvest were nearly equal. Only 5%-8% of fish caught were not retained. Harvest occurred primarily during a small window between 17 July and 4 August with the peak harvest (3,496) of both strata combined occurring on 23 July (Figure 3 and Figure 4).

Table 1.-Estimated effort (angler-hours), catch, harvest, and snag during each stratum of the recreational fishery for sockeye salmon in the downstream section of the Kenai River, 1 July-15 August 1994.

Stratum[a]	Estimate	Standard Error	95% Confidence Interval	Relative Precision
		EFFORT		
Stratum A	53,844	3,772	46,451 - 61,237	13.7
Stratum B	63,204	3,485	56,372 - 70,036	10.8
Total	117,048	5,136	106,982 - 127,114	8.6
		CATCH		
Stratum A	12,228	1,801	8,697 - 15,759	28.9
Stratum B	12,740	1,538	9,725 - 15,754	23.7
Total	24,968	2,369	20,325 - 29,610	18.6
		HARVEST		
Stratum A	11,624	1,651	8,389 - 14,860	27.8
Stratum B	11,773	1,446	8,939 - 14,606	24.1
Total	23,397	2,194	19,096 - 27,698	18.4
		SNAG		
Stratum A	5,582	1,226	3,179 - 7,985	43.0
Stratum B	8,709	1,563	5,646 - 11,772	35.2
Total	14,291	1,986	10,398 - 18,184	27.2

[a] Stratum A is the Warren Ames Bridge to the sonar counters; Stratum B is the sonar counters to the Soldotna Bridge.

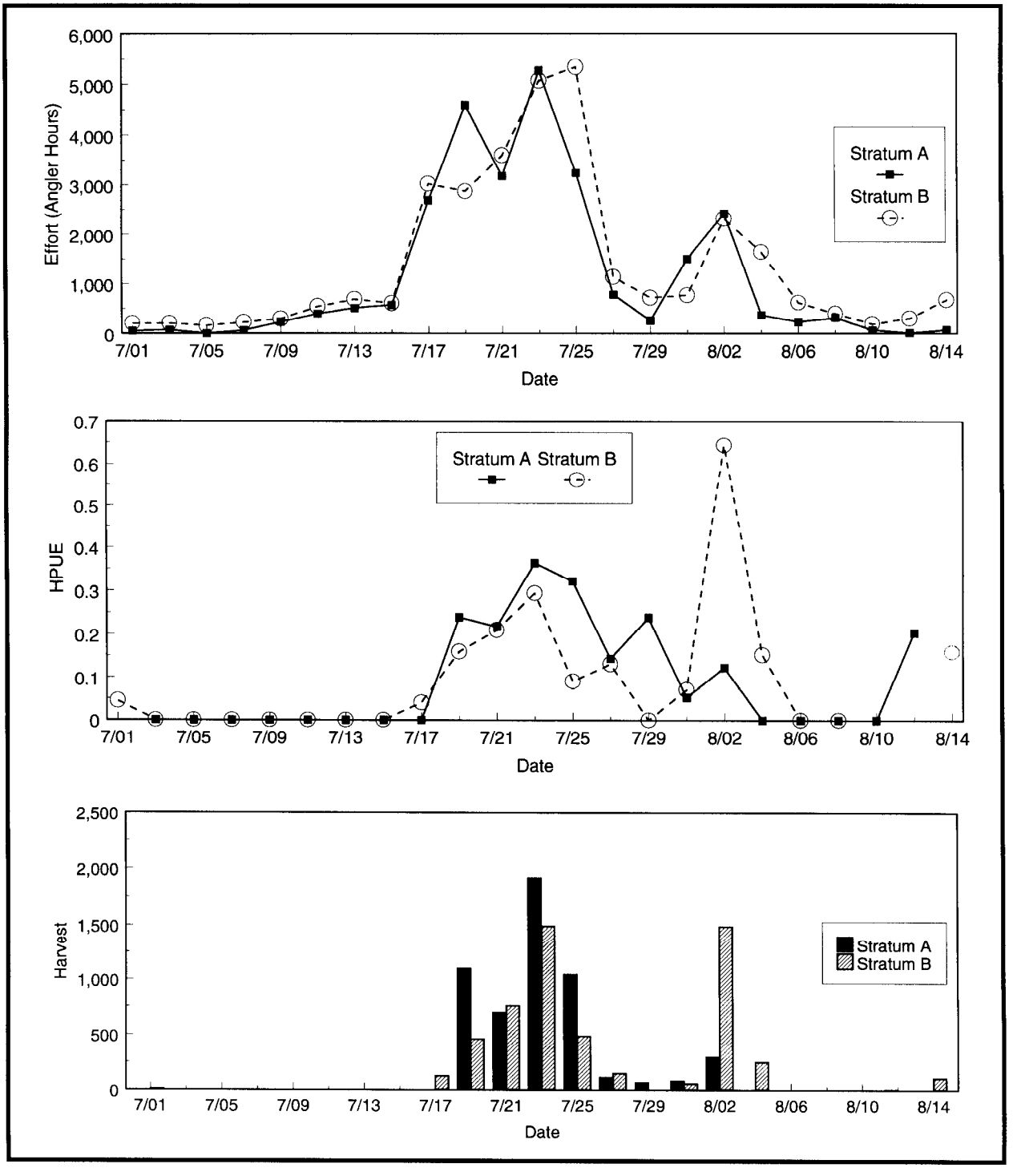

Figure 3.-Effort (angler hours), HPUE, and harvest for Stratum A (Warren Ames bridge to sonar counters) and Stratum B (sonar counters to the Soldotna Bridge) of the sport fishery for sockeye salmon on the Kenai River, 1 July-15 August 1994.

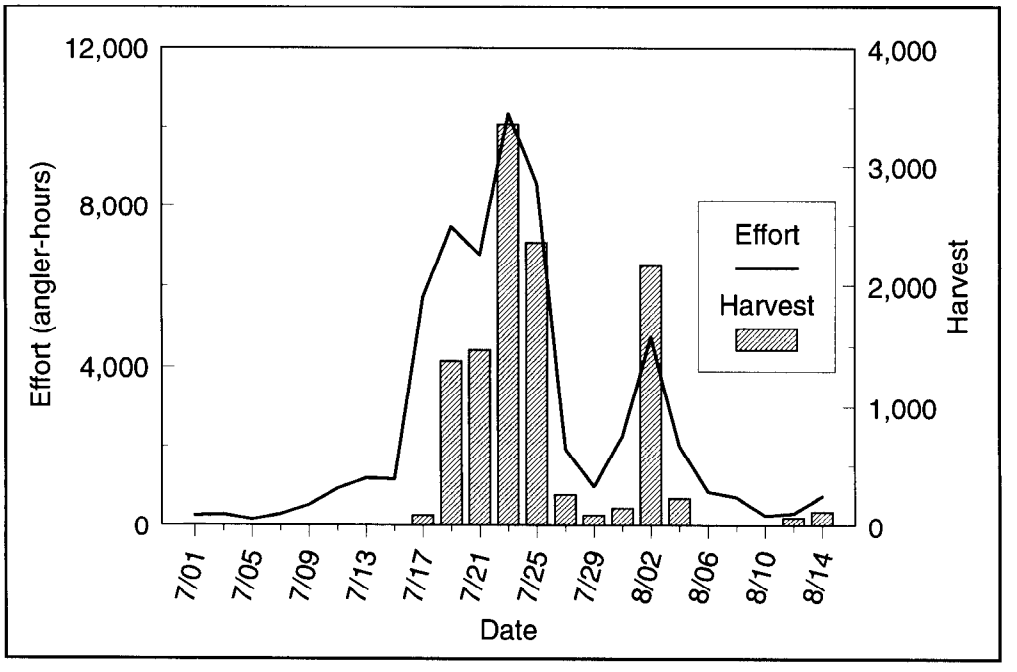

Figure 4.-Effort and harvest in the recreational fishery for sockeye salmon on the Kenai River, downstream section (Strata A and B combined), 1994.

Catch and harvest rates were similar between strata. The CPUE estimates for Strata A and B were 0.23 and 0.20, respectively; and the HPUE estimates were 0.22 and 0.19, respectively (Table 2). The highest HPUE (0.64) occurred on 2 August in Stratum B. It was nearly twice that of the HPUE occurring on 23 July, the next highest HPUE (Figure 3).

Snag

Although not significantly different ($z = 1.57$, $P = 0.12$), the number of snagged fish was greater in Stratum B (8,709, SE = 1,563) than in Stratum A (5,582, SE = 1,226) (Table 1). The SPUE estimates were similar for both areas: 0.10 in Stratum A and 0.14 in Stratum B (Table 2).

Summary

Estimates of effort, catch and harvest were within desired levels of precision (±25%), however the estimate for snagging had a slightly high relative precision (27.2).

Harvest and effort estimates were similar between the two strata, contrary to what was expected considering that Stratum A is 23.3 km (14.5 river miles) in length versus 2.4 km (1.5 river miles) for Stratum B. Perhaps harvest and effort were similar because Stratum A, although covering more river miles than Stratum B, lacks public access sites which can accommodate large numbers of anglers and are in desirable fishing locations for sockeye salmon. The large harvest on 2 August in Stratum B was also greatly responsible for total harvest in this section being similar to the harvest in Stratum A. On most sample days, harvest in Stratum A equaled or surpassed harvest in Stratum B (Figure 3).

Table 2.-Angler effort, catch, CPUE, harvest, HPUE, snag, and SPUE of sockeye salmon in the downstream section of the Kenai River, 1 July-15 August 1994.

	Effort	Catch		Harvest		Snag	
Stratum[a]	Estimate	Estimate	CPUE	Estimate	HPUE	Estimate	SPUE
Stratum A	53,844	12,228	0.23	11,624	0.22	5,582	0.10
Stratum B	63,204	12,740	0.20	11,773	0.19	8,709	0.14
Total	117,048	24,968	0.21	23,397	0.20	14,291	0.12

[a] Stratum A is Warren Ames Bridge to sonar counters; Stratum B is sonar counters to Soldotna Bridge.

The timing of the 1994 late-run sockeye salmon return to the Kenai River was atypical and affected the characteristics of the recreational fishery. Typically the late run peaks during the third or fourth week of July, when anglers converge in high numbers to participate in this fishery. Angler participation increased substantially on 17 July and plummeted after 25 July (Figure 4). Many anglers departed from the area as a result of declining angler success and daily sonar counts (Appendix C3). On 31 July sonar counts began to increase. Peak passage of sockeye salmon occurred on 2 August, the latest on record. Anglers remaining in the area experienced a very successful fishery on 2 August. Although the harvest was not as high as 23 July, the HPUE nearly doubled. Thus, two peaks in harvest occurred in 1994, and an exceptionally high HPUE occurred on 2 August.

The events of the 1994 sockeye salmon fishery support the hypothesis that angler success during this fishery is directly related to fish abundance. Trends in the daily HPUE of the 1994 sockeye salmon recreational fishery in the downstream section were very similar to trends in the sonar counts (Figure 3 and Figure 5). There was a positive linear relationship (b_1 = 0.0000059; $SE(b_1)$ = 0.000001; R^2 = 0.70; F = 32.0; df = 1, 12; P < 0.01) of daily HPUE as a function of sonar counts for anglers fishing in Stratum B. Further analysis of this relationship will be addressed in the fishery survey section.

Liberalizing fishing regulations to allow the retention of snagged fish could increase the legal catch by greater than 50% (Figure 6). The estimated number of fish snagged was 61% of those in the harvest and 57% of those in the catch for both strata combined. As with HPUE, a positive linear relationship (b_1 = 0.0000046; $SE(b_1)$ = 0.0000012; R^2 = 0.70; F = 14.8; df = 1,5; P = 0.01) of daily SPUE as a function of sonar counts (counts of 19,000 to 60,000) existed for anglers in Stratum B; however, when counts were below 19,000 the SPUE tended to be 0 and when counts exceeded 60,000 the SPUE increased dramatically, no longer being a linear relationship. Essentially, the incidence of snagging was rare at sonar counts below 19,000, but as counts increased so did snagging success.

By summing the harvest estimate of Stratum A with the cumulative sonar count, the total 1994 inriver return of sockeye salmon was estimated to be 1,015,070 (Figure 5).

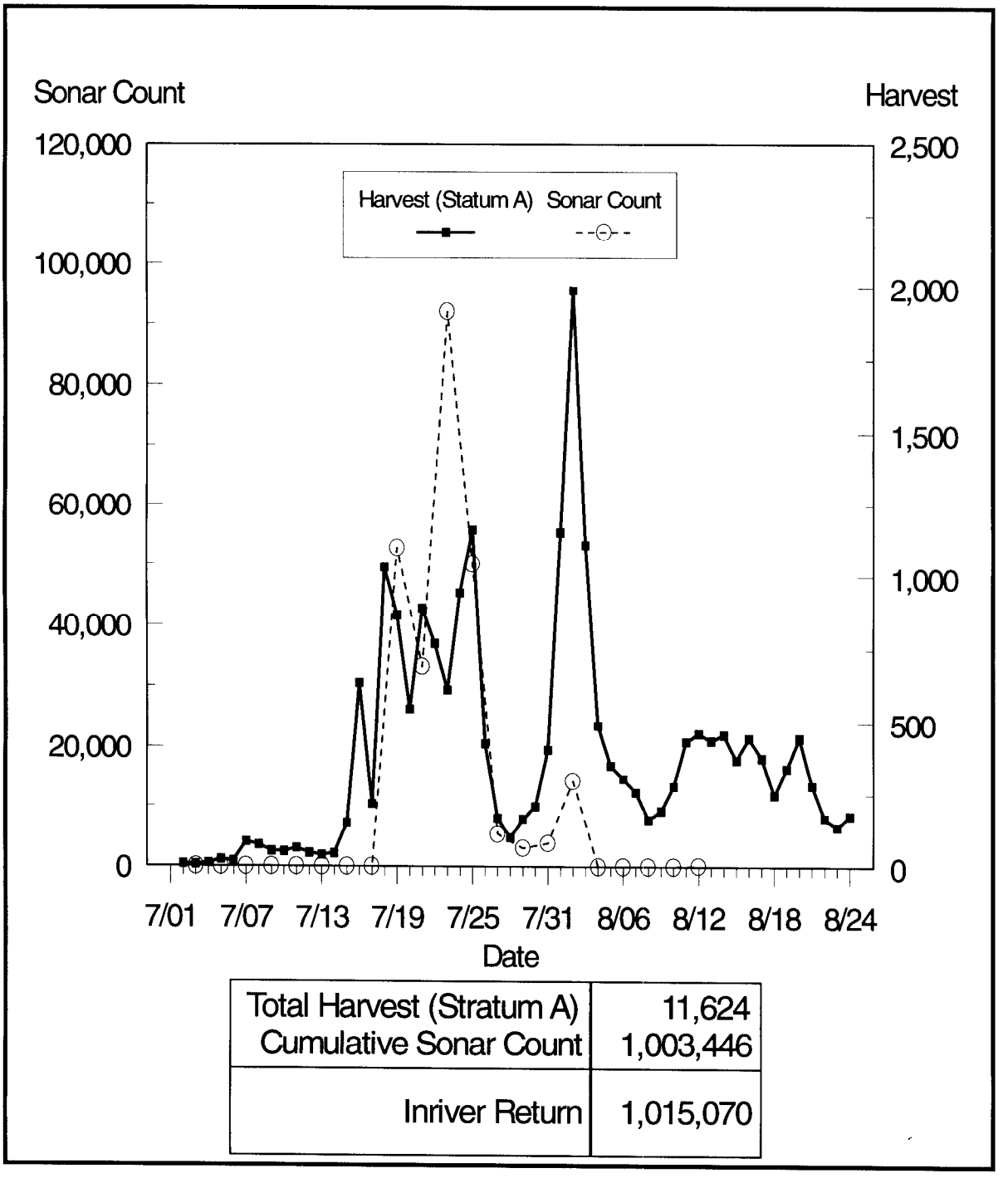

Figure 5.-Inriver return of sockeye salmon determined by sonar counts and harvest by the sport fishery in Stratum A (Warren Ames Bridge to sonar counters) of the Kenai River, 1994.

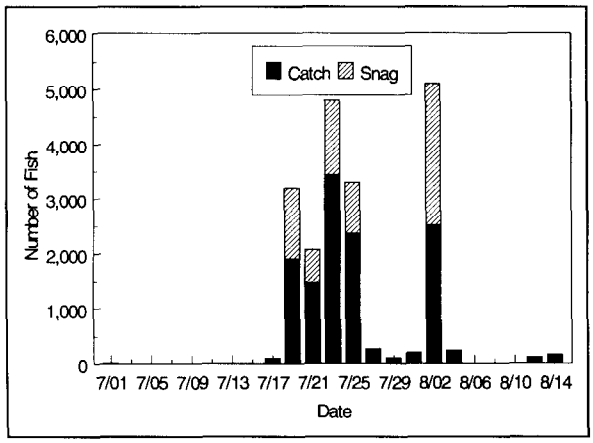

Figure 6.-Number of sockeye salmon caught and snagged in the downriver section (Strata A and B combined) during the recreational fishery on the Kenai River, 1994.

The 1994 harvest estimate for the entire downstream section (Strata A and B combined) was 23,397 fish. Harvest estimates from this creel survey and from the Statewide Harvest Survey (SWHS) (Mills 1982-1994) indicate a decreasing harvest since 1992 (Figure 7).

FISHERY SURVEY

During the fishery survey there were 835 completed-day interviews: 378 from the downriver section, 192 from the midriver section, and 265 from the upriver section. A daily summary of completed-day angler interviews for catch, harvest and snag appears in Appendix C4.

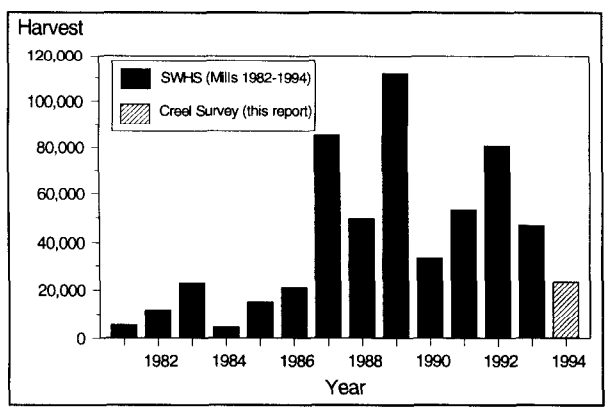

Figure 7.-Estimates of harvest of sockeye salmon by the recreational fishery in the downstream section of the Kenai River, 1981-1994.

Demographics and Angler Behavior

Based on all completed-day anglers interviewed, 17% were residents of the Kenai Borough (local), 37% were from other areas of Alaska (Alaska), 42% were from the United States other than Alaska (U.S.) and 4% were from other countries (other) (Figure 8). The river section where anglers completed their fishing day was significantly different

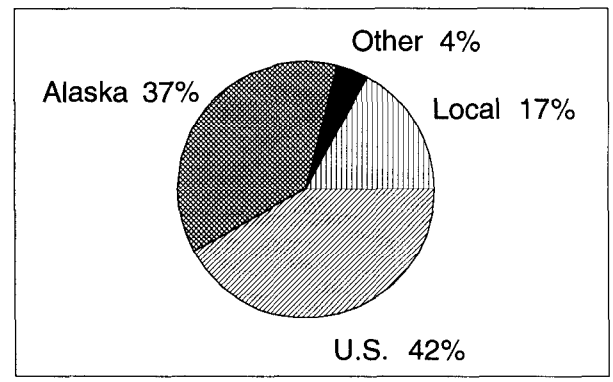

Figure 8.-Residency of anglers participating in the sockeye salmon recreational fishery on the Kenai River, 15 July-15 August 1994.

(χ^2 = 123.7, df = 6, P < 0.005) among residency categories. Residents of the Kenai Borough tended to complete their fishing day, with relatively few interviewed, in the upriver section. The reverse was true of "Alaska" residents: higher numbers than expected were interviewed in the upriver section and lower numbers than expected were interviewed in the downriver section.

The majority of interviewed anglers began their fishing day between 0800 hours and 1159 hours, particularly those who completed their fishing day in the upriver section (Figure 9). There was a substantial decrease in the

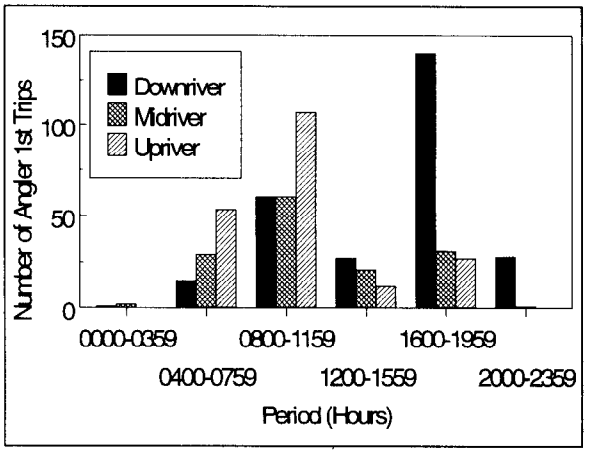

Figure 9.-Start time for anglers' first trip of the day by 4-hour periods and by river section during the recreational fishery for sockeye salmon on the Kenai River, 15 July-15 August 1994.

number of interviewed anglers who began their fishing day during the afternoon (1200 hours-1559 hours) compared to morning periods (0400 hours to 1159 hours). Between 1600 hours and 1959 hours the number of interviewed anglers increased slightly for the midriver and upriver sections compared to the afternoon (1200 hours to 1559 hours), but increased to the highest incidence for the day for those interviewed in the downriver section. This was likely due to local residents entering the fishery after work hours. Note that the number of anglers in each period of start times should not be construed to reflect effort during that period. These numbers are not indicative of the total anglers present during that time, but merely anglers beginning their angling day at that time.

Anglers tended to report fishing days to the whole hour rather than to the half-hour (Appendix C5). Therefore, length of fishing day categories were rounded up to make whole-hour categories. For example, fishing day lengths of 0.5 and 1 hour were combined, 1.5 and 2 hours were combined, etc.

Fishing days of 5 hours or more were more common for anglers interviewed in the upriver section. Anglers who completed their fishing day in the downriver section tended to have fewer hours in their fishing day, usually 5 or less (Figure 10). The median fishing day was 3.5 hours.

Angler Success

The harvest data were poststratified into 1-week intervals by river section (Table 3) and χ^2 tests were used to detect differences of angler success among time periods and among river sections. Although a difference in angler success was detected among time intervals in the downriver ($\chi^2 = 33.06$, df = 9, $P < 0.01$) and upriver ($\chi^2 = 30.04$, df = 9, $P < 0.01$)

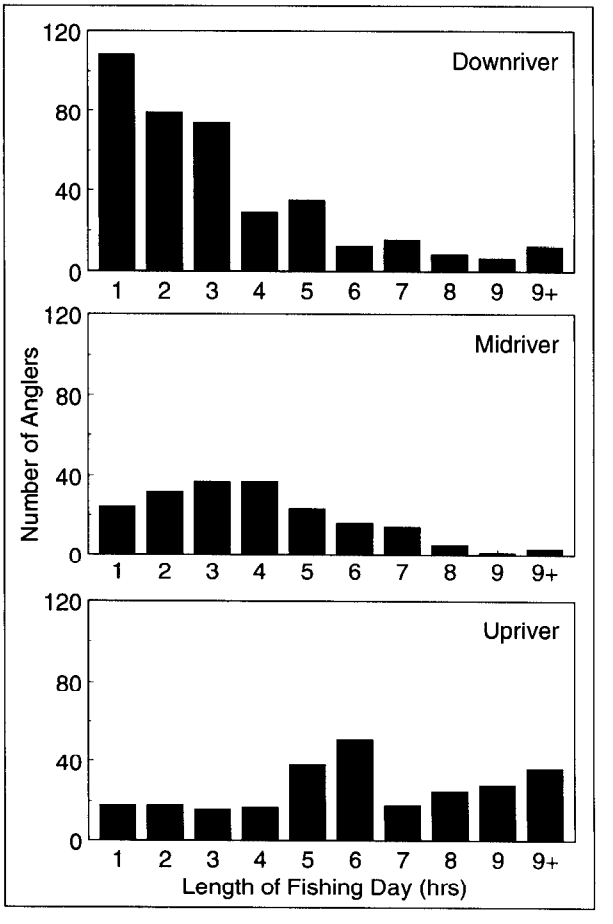

Figure 10.-Number of anglers, by length of fishing day and river section, during the sport fishery for sockeye salmon on the Kenai River, 15 July-15 August 1994.

sections, this was likely due to changes in fish abundance over time, as discussed with the downriver creel estimates, so differences among time intervals in and of themselves have no management implications.

The number of fish harvested per angler day varied among river sections ($\chi = 37.3$, df = 6, $P < 0.001$). Since this difference was also related to fish abundance, the data remained stratified by river section which may provide

Table 3.-Harvest distribution of completed-day anglers, by period and river section, during the recreational fishery in the Kenai River, 15 July-15 August 1994.

	Downriver			Midriver			Upriver		
Harvest	Number of Anglers	%	SE	Number of Anglers	%	SE	Number of Anglers	%	SE
15 - 22 July									
0	100	74	4	36	52	6	9	60	13
1	14	10	3	9	13	4	5	33	12
2	10	7	2	3	4	2	1	7	6
3+[a]	11	8	2	21	30	6	0		
23 -30 July									
0	80	58	4	16	35	7	59	76	5
1	26	19	3	10	22	6	10	13	4
2	9	7	2	7	15	5	3	4	2
3+[a]	23	17	3	13	28	7	6	8	3
31 July - 7 August									
0	58	65	5	25	44	7	81	70	4
1	4	4	2	7	12	4	16	14	3
2	3	3	2	7	12	4	10	9	3
3+[a]	24	27	5	18	32	6	8	7	2
8 - 15 August									
0	15	94	6	14	70	10	24	42	7
1	0			2	10	7	16	28	6
2	1	6	6	1	5	5	3	5	3
3+[a]	0			3	15	8	14	25	6
Total									
0	253	67	2	91	47	4	173	65	3
1	44	12	2	28	15	3	47	18	2
2	23	6	1	18	9	2	17	6	2
3+[a]	58	15	2	55	29	3	28	11	2

[a] Harvest equals three or more sockeye salmon.

some insights for future management. Greater than 45% of all anglers interviewed failed to harvest any sockeye salmon (Table 3 and Table 4; Figure 11). The percent of interviewed anglers harvesting a total of one or two fish was similar in all sections of the river (12%-18% for one fish and 6%-9% for two fish); however, the percent of anglers harvesting three or more fish was higher for those who completed their fishing day in the midriver section (29%) than those exiting the fishery from the downriver (15%) and upriver (11%) sections.

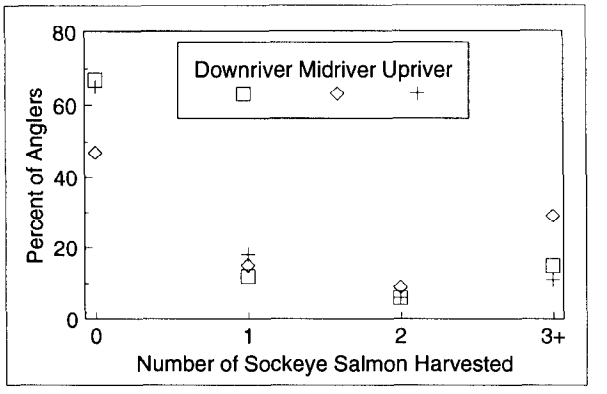

Figure 11.-Percent of anglers by number of sockeye salmon harvested in three river sections during the recreational fishery on the Kenai River, 15 July-15 August 1994.

Anglers who completed their fishing day in the midriver section tended to have the best success harvesting sockeye salmon (Table 5). Fifty-three percent harvested at least one fish (33% and 35% in the downriver and upriver sections, respectively), 38% harvested two or more fish (21% and 17% in the downriver and upriver sections, respectively), and 29% harvested three or more fish (15% and 11% in the downriver and upriver sections, respectively). After the bag limit was liberalized to six fish, only anglers interviewed in the upriver section actually retained more than three fish. Of note, the percent of the catch was nearly equal to the percent of the harvest for those anglers interviewed in the downriver and midriver sections whereas in the upriver section the percent catch was much higher than the percent harvest (Table 5 and Figure 12). The greater incidence of release of fish in the upriver section may have been due to reduced quality of the fish from physiological changes caused by maturation and time in fresh water.

Snagging of at least one fish increased from 15% in the downriver section to 35% in the upriver section (Table 5 and Figure 12). This may be the result of fish behavior. When sockeye salmon first enter the river they typically move rapidly through the downriver section. As they near their spawning areas, sockeye salmon become less responsive to rheotaxis and begin milling, making them more susceptible to snagging.

Table 4.-Daily harvest per interviewed completed-day angler by river section during the recreational fishery for sockeye salmon on the Kenai River, 15 July-15 August 1994.

	Harvest per Angler				
River Section	0	1	2	3+ [a]	Total
Downriver	253	44	23	58	378
Midriver	91	28	18	55	192
Upriver	173	47	17	28 [b]	265
Total	517	119	58	141	835

[a] Number of anglers harvesting three or more fish.

[b] Includes 4 anglers with 6 fish each, 1 angler with 5 fish, and 1 angler with 4 fish.

Table 5.-Distribution of harvest, catch, and snag of completed-day anglers by river section during the recreational fishery for sockeye salmon on the Kenai River, 15 July-15 August 1994.

No. of Fish[a]	Downriver Anglers Number	%	SE	95% Confidence Interval	Midriver Anglers Number	%	SE	95% Confidence Interval	Upriver Anglers Number	%	SE	95% Confidence Interval
HARVEST												
0	253	67	2	62 - 72	91	47	4	40 - 54	173	65	3	60 - 71
1+	125	33	2	28 - 38	101	53	4	46 - 60	92	35	3	29 - 40
2+	81	21	2	17 - 26	73	38	4	31 - 45	45	17	2	12 - 21
3+	58	15	2	12 - 19	55	29	3	22 - 35	28	11	2	7 - 14
4+	0				0				6	2	1	0 - 4
5+	0				0				5	2	1	0 - 4
6	0				0				4	2	1	0 - 3
CATCH												
0	247	65	2	61 - 70	91	47	4	40 - 54	138	52	3	46 - 58
1+	131	35	2	30 - 39	101	53	4	46 - 60	127	48	3	42 - 54
2+	82	22	2	18 - 26	73	38	4	31 - 45	82	31	3	25 - 37
3+	61	16	2	12 - 20	57	30	3	23 - 36	56	21	3	16 - 26
4+	5	1	1	0 - 2	12	6	2	3 - 10	34	13	2	9 - 17
5+	1	<1	<1	0 - 1	8	4	1	1 - 7	25	9	2	6 - 13
6+	0				5	3	1	0 - 5	20	8	2	4 - 11
SNAG												
0	322	85	2	82 - 89	147	77	3	71 - 83	173	65	3	60 - 71
1+	56	15	2	11 - 18	45	23	3	17 - 29	92	35	3	29 - 40
2+	44	12	2	8 - 15	23	12	2	7 - 17	69	26	3	21 - 31
3+	24	6	1	4 - 9	11	6	2	2 - 9	46	17	2	13 - 22
4+	16	4	1	2 - 6	8	4	1	1 - 7	35	13	2	9 - 17
5+	11	3	1	1 - 5	7	4	1	1 - 6	26	10	2	6 - 13
6+	8	2	1	1 - 4	5	3	1	0 - 5	21	8	2	5 - 11

[a] "+" refers to equal or greater than the number, i.e., 1+ means one or more fish.

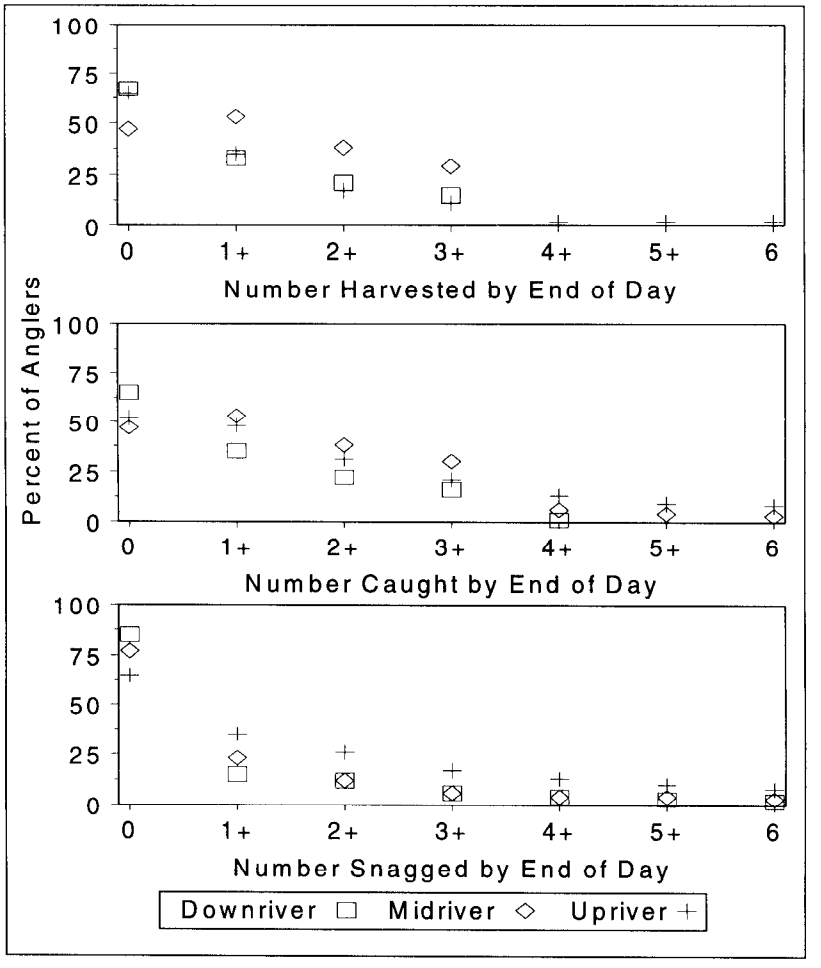

Figure 12.-Distribution of harvest, catch, and snag of sockeye salmon in the downriver, midriver, and upriver sections of the Kenai River during the recreational fishery, 15 July-15 August 1994.

Summary

During the 1994 fishery the three fish bag limit did reduce harvest since 17% of the interviewed anglers harvested three fish (Table 4).

For the 1994 fishery, a reduction in the bag limit would have had similar effects in all three river sections. For example, the proportion of fish harvested third or later varied little between river sections (Table 6 and Figure 13) so a two-fish bag limit would have had the overall effect of a 22%-24% reduction in harvest in each section. Assuming effort is not affected by bag limit reductions, a two-fish bag limit would have reduced harvest by 23% and a one-fish bag limit would have reduced harvest by 53% in 1994.

As discussed earlier, harvest success of anglers interviewed in the downriver section improved with an increase of fish abundance. For anglers who completed their fishing day in the downriver section, there was a significant increase ($b_1 = 0.000022$; $SE(b_1) = 0.000003$; $R^2 = 0.85$; $F = 75.9$, $df = 1, 12$; $P < 0.001$) in the mean daily harvest as a function

Table 6.-Numbers of sockeye salmon harvested by completed-day anglers, by river section, during the recreational fishery on the Kenai River, 15 July-15 August 1994.

	Fish Position in Creel						Sample
	1	2	3	4	5	6	Total
Downriver							
Harvest	125	81	58	0	0	0	264
% of Total	47.3	30.7	22.0	0.0	0.0	0.0	100
SE(%)	1.8	1.1	1.4				
Midriver							
Harvest	101	73	55	0	0	0	229
% of Total	44.1	31.9	24.0	0.0	0.0	0.0	100.0
SE(%)	1.7	1.0	1.4				
Upriver							
Harvest	92	45	28	6	5	4	180
% of Total	51.1	25.0	15.6	3.3	2.8	2.2	100.0
SE(%)	3.5	1.7	1.7	1.1	1.0	0.9	
Total							
Harvest	318	199	141	6	5	4	673
% of Total	47.3	29.6	21.0	0.9	0.7	0.6	100.0
SE(%)	1.3	0.7	0.9	0.3	0.3	0.3	

of increasing sonar counts. Angler harvest success was significantly lower (χ^2= 67.4, df = 3, P <0.001) among days when fish passage was below the median count (20,973) versus days when counts were above the median (Table 7). When fish passage was below the median, 92% of the anglers had zero harvest, but when fish passage exceeded the median only 52% of the anglers had zero harvest. Therefore, the impact of bag limit modifications on angler harvest success is dependent upon fish passage. For example, if the bag limit were reduced to two fish, on days when fish passage was below the median there would have been almost no reduction in harvest; however, on days when fish passage exceeded the median the harvest by anglers interviewed in the downriver section would have been reduced by 23% (Table 7).

Relating daily fish passage at the sonar site to success of anglers who completed their fishing day at the midriver and upriver

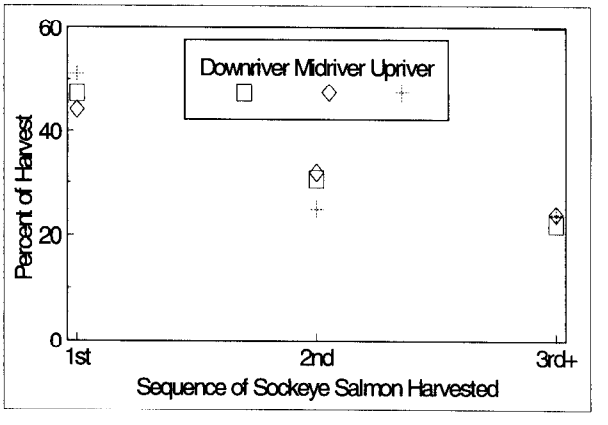

Figure 13.-Percent of anglers by sequence of sockeye salmon harvested in three river sections during the recreational fishery on the Kenai River, 15 July-15 August 1994.

sections was not done because the lag time for fish movement through those sections is unknown. This was complicated by fish exiting to spawn in tributaries and Skilak

Lake as well as sparse data: (1) anglers not interviewed every day in each section, and (2) few anglers interviewed late in the season in the upriver section.

Table 7.-Number of completed-day anglers by harvest level, and harvest by sequence of fish harvested, in relation to the median sonar count, during the recreational sockeye salmon fishery in the downstream section of the Kenai River, 15 July-15 August 1994.

	Harvest per Angler				Total	Fish Position in Creel			Total
Fish Passage	0	1	2	3	Anglers	1	2	3	Harvest
Below median[a]	128	9	2	0	139	11	2	0	13
Above median[a]	125	35	21	58	239	114	79	58	251
Total	253	44	23	58	378	125	81	58	264

[a] Median sonar count for the study period was 20,973.

RECOMMENDATIONS

High variability of angler counts for the creel survey in Stratum A greatly increased the variances of the catch and harvest estimates. Increasing the number of counts per period would reduce the variance and might improve the relative precision for catch and harvest estimates, depending upon other characteristics of the fishery. Increasing the length of the sample day to 0400-2400 hours would also be advantageous. Observation of the fishery indicated that when fish abundance was high angler participation remained high after 2200 hours but was noticeably reduced after 2400 hours.

We did not meet the sample goal of 403 interviews per stratum for the 1994 fishery survey. Insufficient interviews were collected in all three strata: downriver, 378; midriver, 192; and upriver, 265. The atypical characteristics of the 1994 fishery are partly responsible for the low number of interviews. As this was the first year of the survey there was much to be learned about angler preference for various access sites. Some access sites were not known and others were not as popular as believed. In 1995 the preferred access sites should be sampled more frequently. Obtaining the sample goal in the midriver section may still be difficult because many anglers use private access sites.

In years when the personal use dip net fishery occurred the harvest was estimated through the SWHS. When the subsistence fishery occurs, as it did in 1994, the harvest is reported by participants postseason. These estimates are important in determining the total inriver return of sockeye salmon. It would be prudent to conduct a creel survey on these fisheries to provide a standard comparison with the SWHS estimates.

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APPENDIX A: KENAI RIVER SOCKEYE SALMON MANAGEMENT PLAN

Appendix A1.-5 AAC 21.360. Kenai River sockeye salmon management plan.

I. The purpose of this management plan is to ensure an adequate escapement, as determined by the department, of sockeye salmon into the Kenai River system and to provide management guidelines to the department in an effort to preclude allocation conflicts between the various users of this resource. This plan will govern only those sockeye salmon which pass the department sonar counters, located near Soldotna, after June 21. Sockeye salmon in the Kenai River before this date are primarily of Russian River origin and are managed as a discrete stock as provided for in 5 AAC 21.361.

II. The department shall manage the Cook Inlet commercial salmon gillnet fishery to attain a total sockeye salmon run of 400,000 to 700,000 into the Kenai River after June 21 to insure an adequate spawning escapement and provide for a recreational harvest.

III. The department shall manage the recreational fishery on the Kenai River to insure adequate spawning escapement as follows:

A. if the projected Kenai River sockeye salmon escapement is less than 400,000 fish, the department shall close the recreational fishery for sockeye salmon;

B. if the projected Kenai River sockeye salmon escapement is 400,000 fish to 700,000 fish, the department shall manage the recreational fishery for sockeye salmon for a guideline harvest of ten percent of the projected escapement; to achieve the guideline harvest level, the department shall establish periods by emergency order during which:

1. fishing time is reduced;

2. bag or possession limits are two fish; or

3. bag or possession limits are one fish;

C. if the projected Kenai River sockeye salmon escapement is greater than 700,000 fish, the department shall open a recreational fishery for sockeye salmon during which the bag and possession limit is six fish.

APPENDIX B: COOK INLET PERSONAL USE SALMON DIP NET FISHERY MANAGEMENT PLAN

Appendix B1.-5 AAC 77.545. Cook Inlet personal use salmon dip net fishery management plan.

I. Salmon, other than king salmon, may be taken with a dip net only in an area and during a season established by emergency order. The department may not allow the taking of salmon with a dip net in the Kenai River until an inriver run of 700,000 sockeye salmon, as measured by the sonar counters at river mile 19, is assured. The fishery shall close on July 31. The department may not allow the taking of salmon with a dip net in the Kasilof River until the minimum escapement goal of 250,000 sockeye salmon is assured. The department may allow the taking of salmon with a dip net in a location where an artificially produced salmon stock is returning to an area that has no spawning grounds available for that salmon stock.

II. In the Kenai River, dip nets may be used to take salmon in the area from ADF&G regulatory markers located on the Cook Inlet beaches outside the terminus of the river upstream to the downstream side of the Warren Ames or new Kenai-Soldotna highway bridge.

APPENDIX C: SUPPORTING STATISTICS

Appendix C1.-Daily shore angler counts and summary statistics by stratum during the recreational fishery for sockeye salmon in the downriver section of the Kenai River, 1 July-15 August 1994.

	Stratum B Counts[a]					Stratum A Counts[b]				
Date	#1	#2	#3	Mean	Variance	#1	#2	#3	Mean	Variance
1-Jul	3	20	12	12	29	0	0	9	3	7
3-Jul	0	8	27	12	35	0	0	12	4	12
5-Jul	0	0	27	9	61	0	0	0	0	0
7-Jul	0	11	27	13	31	0	0	11	4	10
9-Jul	0	15	34	16	49	0	18	21	13	28
11-Jul	17	36	37	30	30	2	29	35	22	64
13-Jul	23	43	48	38	35	14	47	24	28	135
15-Jul	4	43	54	34	137	0	29	66	32	184
17-Jul	158	226	119	168	1,339	61	200	187	149	1,624
19-Jul	33	225	220	159	3,074	78	362	326	255	6,829
21-Jul	115	229	256	200	1,144	125	250	155	177	2,054
23-Jul	155	275	415	282	2,833	151	395	332	293	5,292
25-Jul	217	403	269	296	4,379	147	214	179	180	476
27-Jul	59	75	56	63	51	26	97	7	43	1,095
29-Jul	31	35	54	40	31	4	26	14	15	52
31-Jul	17	61	50	43	171	23	90	137	83	558
2-Aug	60	103	223	129	1,354	57	134	212	134	1,001
4-Aug	45	141	87	91	1,011	0	27	35	21	66
6-Aug	0	59	44	34	309	2	15	22	13	18
8-Aug	15	31	21	22	30	3	42	8	18	223
10-Aug	14	10	8	11	2	3	2	7	4	2
12-Aug	3	0	48	17	193	0	0	2	1	0
14-Aug	12	63	38	38	269	4	7	2	4	3

[a] Stratum B is the sonar counters to the Warren Ames Bridge.

[b] Stratum A is the Soldotna Bridge to the sonar counters.

Appendix C2.-Daily summary statistics for number of anglers interviewed, estimated fishing effort (E), and estimated HPUE, harvest (H), CPUE, catch (C), SPUE, and snag (S) of sockeye salmon, by stratum, for shore anglers interviewed during the fishery for sockeye salmon in the downstream section of the Kenai River, 1 July-15 August 1994.

		Anglers	Effort		HPUE		Harvest		CPUE		Catch		SPUE		Snag	
Date	Stratum[a]	Interviewed	E	Variance	Mean	Variance	H	Variance	Mean	Variance	C	Variance	Mean	Variance	S	Variance
1-Jul	A		54	2,187												
	B	14	210	9,531	0.0446	0.0012	9	59	0.0446	0.0012	9	59	0.0000	0.0000	0	0
3-Jul	A	1	72	3,888	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	1	210	11,475	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
5-Jul	A	1	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	10	162	19,683	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
7-Jul	A	1	66	3,267	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	7	228	10,179	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
9-Jul	A	10	234	8,991	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	6	294	15,822	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
11-Jul	A	4	396	20,655	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	6	540	9,774	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
13-Jul	A	13	510	43,686	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	2	684	11,475	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
15-Jul	A	11	570	59,670	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	13	606	44,334	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
17-Jul	A	36	2,688	526,230	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	21	3,018	433,971	0.0409	0.0019	123	17,145	0.0409	0.0019	123	17,145	0.0000	0.0000	0	0
19-Jul	A	16	4,596	2,212,704	0.2393	0.0165	1,100	438,838	0.2803	0.0234	1,288	615,975	0.2025	0.0117	931	312,404
	B	29	2,868	996,003	0.1597	0.0060	610	108,340	0.2126	0.0088	458	68,555	0.1606	0.0070	460	76,213
21-Jul	A	19	3,180	665,550	0.2177	0.0203	692	223,541	0.2177	0.0203	692	223,541	0.0000	0.0000	0	0
	B	16	3,600	370,575	0.2096	0.0144	755	197,226	0.2096	0.0144	755	197,226	0.1597	0.0063	575	88,657
23-Jul	A	36	5,268	1,714,635	0.3637	0.0101	2,003	549,623	0.3802	0.0116	1,916	489,827	0.1813	0.0088	955	285,910
	B	35	5,070	918,000	0.2945	0.0061	1,493	229,759	0.2945	0.0061	1,493	229,759	0.0797	0.0024	404	65,418
25-Jul	A	33	3,240	154,278	0.3221	0.0033	1,044	49,723	0.3221	0.0033	1,044	49,723	0.1006	0.0023	326	25,600
	B	10	5,334	1,418,904	0.0910	0.0045	485	134,661	0.0910	0.0045	485	134,661	0.1360	0.0111	725	327,484
27-Jul	A	14	780	354,807	0.1439	0.0033	112	8,186	0.1439	0.0033	112	8,186	0.0000	0.0000	0	0
	B	27	1,140	16,659	0.1311	0.0053	149	7,143	0.1311	0.0053	149	7,143	0.0000	0.0000	0	0
29-Jul	A	12	264	16,956	0.2387	0.0300	63	2,551	0.2387	0.0300	63	2,551	0.0000	0.0000	0	0
	B	12	720	10,179	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
31-Jul	A	18	1,500	180,846	0.0531	0.0028	80	6,337	0.0531	0.0028	80	6,337	0.0000	0.0000	0	0
	B	28	768	55,539	0.0710	0.0010	55	830	0.0710	0.0010	55	830	0.0300	0.0008	23	503

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Appendix C2.-Page 2 of 2.

Date	Stratum[a]	Anglers Interviewed	Effort E	Effort Variance	HPUE Mean	HPUE Variance	Harvest H	Harvest Variance	CPUE Mean	CPUE Variance	Catch C	Catch Variance	SPUE Mean	SPUE Variance	Snag S	Snag Variance
2-Aug	A	18	2,418	324,351	0.1231	0.0060	298	37,918	0.1231	0.0060	298	37,918	0.1385	0.0081	335	51,015
	B	33	2,316	438,723	0.6438	0.0086	1,749	285,193	0.7551	0.0071	1,491	224,390	0.7719	0.0482	1,788	499,029
4-Aug	A	8	372	21,411	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	18	1,638	327,564	0.1526	0.0104	250	32,159	0.1526	0.0104	250	32,159	0.0000	0.0000	0	0
6-Aug	A	10	234	5,886	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	18	618	100,062	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
8-Aug	A	9	318	72,279	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B	7	402	9,612	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
10-Aug	A	1	72	702	0.0000	0.0000	0	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
	B		192	540												
12-Aug	A	4	12	108	0.2042	0.0627	2	7	0.2042	0.0627	2	7	0.1199	0.0144	1	2
	B		306	62,451												
14-Aug	A		78	918												
	B	6	678	87,102	0.1565	0.0111	138	7,613	0.2036	0.0107	106	6,251	0.0000	0.0000	0	0

[a] Stratum A is the Warren Ames Bridge to the sonar counters. Stratum B is the sonar counters to the Soldotna Bridge.

Appendix C3.-Daily and cumulative sonar estimates of late-run sockeye salmon entering the Kenai River, 1994.

Date	Daily Estimate	Cumulative Estimate
1-Jul		
2-Jul	399	399
3-Jul	301	700
4-Jul	534	1,234
5-Jul	1,091	2,325
6-Jul	859	3,184
7-Jul	4,022	7,206
8-Jul	3,522	10,728
9-Jul	2,495	13,223
10-Jul	2,403	15,626
11-Jul	3,003	18,629
12-Jul	2,200	20,829
13-Jul	1,858	22,687
14-Jul	2,145	24,832
15-Jul	7,204	32,036
16-Jul	30,546	62,582
17-Jul	10,369	72,951
18-Jul	49,484	122,435
19-Jul	41,634	164,069
20-Jul	26,201	190,270
21-Jul	42,744	233,014
22-Jul	37,055	270,069
23-Jul	29,363	299,432
24-Jul	45,222	344,654
25-Jul	55,772	400,426
26-Jul	20,567	420,993
27-Jul	8,027	429,020
28-Jul	4,761	433,781
29-Jul	7,860	441,641
30-Jul	9,935	451,576
31-Jul	19,493	471,069
1-Aug	55,382	526,451
2-Aug	95,473	621,924
3-Aug	53,274	675,198
4-Aug	23,549	698,747
5-Aug	16,884	715,631
6-Aug	14,713	730,344
7-Aug	12,394	742,738
8-Aug	7,796	750,534
9-Aug	9,241	759,775
10-Aug	13,434	773,209
11-Aug	20,892	794,101
12-Aug	22,260	816,361
13-Aug	21,054	837,415
14-Aug	22,078	859,493
15-Aug	17,841	877,334
16-Aug	21,482	898,816
17-Aug	18,149	916,965
18-Aug	11,871	928,836
19-Aug	16,437	945,273
20-Aug	21,492	966,765
21-Aug	13,544	980,309
22-Aug	8,094	988,403
23-Aug	6,578	994,981
24-Aug	8,465	1,003,446

Data from: Davis et al. *In prep*

Appendix C4.-Numbers of anglers harvesting, catching (fair hooked and released), and snagging (foul hooked and released) sockeye salmon, by number of fish harvested, caught, or snagged, by date, during the recreational fishery for sockeye salmon on the Kenai River, 1994.

	Number of Fish																				
Date	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6-20
	Harvest							**Catch**							**Snag**						
15-Jul	18	0	0	0	0	0	0	36	0	0	0	0	0	0	18	0	0	0	0	0	0
16-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Jul	29	5	0	0	0	0	0	63	5	0	0	0	0	0	34	0	0	0	0	0	0
18-Jul	27	4	1	5	0	0	0	64	4	1	5	0	0	0	36	0	1	0	0	0	0
19-Jul	30	9	6	4	0	0	0	66	17	7	7	1	0	0	39	4	5	0	1	0	0
20-Jul	2	0	0	2	0	0	0	6	0	0	2	0	0	0	4	0	0	0	0	0	0
21-Jul	31	6	4	8	0	0	0	79	7	4	8	0	0	0	43	1	2	1	0	0	2
22-Jul	7	6	2	15	0	0	0	35	7	2	15	0	0	1	22	4	2	1	0	0	1
23-Jul	85	19	7	24	0	0	0	201	29	13	24	0	1	2	109	10	7	5	1	2	1
24-Jul	1	5	1	6	0	0	0	13	6	1	6	0	0	0	10	1	1	0	1	0	0
25-Jul	13	11	4	4	0	0	0	45	11	4	4	0	0	0	23	1	3	2	0	1	2
26-Jul	4	3	5	4	0	0	0	16	6	6	4	0	0	0	7	8	1	0	0	0	0
27-Jul	30	5	2	0	0	0	0	67	5	2	0	0	0	0	29	3	3	0	1	0	1
28-Jul	6	1	1	3	0	0	0	17	1	1	3	0	0	0	11	0	0	0	0	0	0
29-Jul	10	0	1	0	0	0	0	21	0	1	0	0	0	0	11	0	0	0	0	0	0
30-Jul	5	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	0
31-Jul	70	9	4	5	0	0	0	147	12	6	8	0	0	3	74	3	5	1	3	0	2
1-Aug	2	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0
2-Aug	12	3	4	23	0	0	0	52	3	5	23	1	0	0	17	5	6	4	3	1	6
3-Aug	2	1	2	14	0	0	0	15	1	4	17	0	1	0	3	7	5	2	0	1	1
4-Aug	30	7	2	2	0	0	0	59	9	6	6	0	1	1	31	3	5	0	0	1	1
5-Aug	3	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	0	0	0	0	0
6-Aug	28	1	1	2	0	0	0	55	3	2	3	1	0	0	26	1	1	0	0	0	4
7-Aug	18	6	5	4	0	0	0	51	6	5	4	0	0	0	29	1	2	0	0	1	0
8-Aug	25	8	3	2	1	1	1	58	11	6	3	1	1	2	27	4	2	4	2	1	1
9-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Aug	1	1	1	1	0	0	3	5	2	3	1	0	0	3	1	1	1	2	0	0	2
11-Aug	7	2	1	2	0	0	0	19	2	1	2	0	0	0	8	1	0	0	0	0	3
12-Aug	11	5	1	4	0	0	0	22	8	1	6	1	1	3	7	2	2	0	3	2	5
13-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Aug	3	2	0	1	0	0	0	8	3	0	1	0	0	0	2	0	0	2	0	0	2
15-Aug	7	0	0	0	0	0	0	13	1	0	0	0	0	0	7	0	0	0	0	0	0

Appendix C5.-Number of anglers, by length of fishing day and river section, during the sport fishery for sockeye salmon on the Kenai River, 15 July-15 August 1994.

	Number of Anglers		
Length of Fishing Day (h)	Downriver	Midriver	Upriver
0.5	37	1	5
1	71	23	13
1.5	29	10	2
2	50	22	16
2.5	25	9	7
3	49	28	9
3.5	3	9	5
4	26	28	12
4.5	5	14	8
5	30	9	30
5.5	2	6	37
6	10	10	14
6.5	3	2	5
7	12	12	13
7.5	0	1	17
8	8	4	8
8.5	5	0	15
9	1	1	13
9.5	0	1	10
10	4	0	15
10.5	2	2	2
11	0	0	8
12	2	0	1
14	4	0	0